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Beriberi Outbreak among Myanmar and Thai workers in a Factory in Chachoengsao Province, Thailand, 2012-2013

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Abstract

Beriberi is a clinical syndrome which develops from prolonged severe thiamine deficiency in diet. In July 2013, the Ministry of Public Health, Thailand received reports of three deaths among Myanmar workers in a factory. We identified suspect beriberi cases, reviewed clinical history and conducted a survey among both Myanmar and Thai workers in the factory. Blood thiamine levels were measured and foods served in the factory canteen were also examined. Seventeen suspect cases (attack rate = 17%) were identified, with median age of 26 years (range 20-30 years) and male to female ratio of 3.3:1. All fatalities were young men (case fatality proportion = 17.6%). Prevalence of thiamine deficiency among Myanmar and Thai workers were 7.1% (95% CI = 0-22.0) and 26.7% (95% CI = 1.3-52.0) respectively. This outbreak was likely to be caused by long exposure to low thiamine intake and heavy physical activities. After distributing thiamine supplements and improving diet, no more cases occurred. We recommended improving hospital staff's ability to differentiate beriberi from other cardiomyopathies and neurologic diseases, and raising awareness of thiamine deficiency in this area.

Key words: beriberi, thiamine deficiency, malnutrition, occupational health

Introduction

Beriberi is a clinical syndrome, resulting from prolonged severe deficiency of thiamine in diet. Thiamine is vitamin B1 which plays a key role in carbohydrate metabolism and also an important factor for function of the nervous system. Persistent thiamine deficiency for 2-3 months can lead to disability and death. It occurs in people with poor diet, anti-thiamine foods (betel nut and fermented fish), heavy physical activities and special conditions like pregnant women, alcoholics and refugee population.[1]

Beriberi can present in adults with cardiomyopathy (cardiac or wet beriberi) and peripheral neuropathy (dry beriberi). Cardiac beriberi can cause edema, high cardiac output and ventricular failure, and death may occur abruptly from congestive heart failure. Dry beriberi is characterized by polyneuropathy with paraesthesia of extremities (especially legs), reduced knee jerk and other tendon reflexes, progressive severe weakness and muscles wasting.[1]

Beriberi has been reported since thousands of years ago and remains in many parts of Asia. Today with rising standards of living, beriberi has become a rare disease all over the world. Despite that since 2000, some beriberi outbreaks were reported in West Africa[2,3], Brazil[4,5,6], Gambia[7], Somalia[8] and Taiwan[9]. In Thailand, one outbreak was reported among commercial fishermen during 2005.[10]

In April 2013, three deaths of unknown cause among Myanmar workers from Factory A in Chachoengsao

Province, Thailand were reported to the Bureau of Occupational and Environmental Diseases (BOED), Department of Disease Control, Ministry of Public Health. As a result of investigation by BOED, they suspected either chemical poisoning or beriberi. Thus, they recommended providing thiamine rich foods (beans) and thiamine supplements to the workers. Two months later, since laboratory results for chemicals were negative, they notified the Bureau of Epidemiology in July 2013 for further investigation. Therefore, our team was sent to conduct an investigation from 10-12 Jul 2013 to verify the outbreak, confirm the diagnosis, determine the cause, and provide recommendations to prevent further cases and deaths.

Methods

Study among Myanmar Workers

A cross-sectional study was conducted among Myanmar workers in the factory during July 2013. Case definition of beriberi was developed after reviewing medical records and interviewing hospital staff, clinicians and head of the factory workers. A suspect case was defined as a Myanmar factory worker with at least two of the followings: leg pain, tingling or burning sensation of extremities, numbness of extremities, unable to elevate leg, chest pain, leg edema, dyspnea or diagnosed with acute heart failure from November 2012 to July 2013.

We conducted active case finding in the factory by interviewing face-to-face with all Myanmar workers using a semi-structured questionnaire and reviewing medical records of patients diagnosed with beriberi in provincial and district hospitals. Venous blood samples were collected from all suspect cases and tested for thiamine pyrophosphate (TPP) levels using high-performance liquid chromatography (HPLC).

Study on Blood Thiamine Level

We conducted a cross-sectional study on prevalence of thiamine deficiency among Thai and Myanmar workers in the factory during July 2013. Of total 180 workers in the factory, 100 were Myanmar while 80 were Thai. We selected approximately one-seventh of Myanmar workers and one-fifth of Thai workers by stratified simple random sampling from lists of Thai and Myanmar workers. A total of 29 workers were selected, including 14 Myanmar and 15 Thai workers. We interviewed each of them using a questionnaire to obtain information on demographics and risk factors for thiamine deficiency. In addition, we tested all sampled workers for blood TPP level using HPLC to identify prevalence of thiamine deficiency. The reference value for TPP in healthy volunteers was 120 ± 17.5 nmol/L.[11] In this outbreak, according to the laboratory that we sent for testing, thiamine deficiency was defined as TPP level of less than 116 nmol/L.

Data Analysis

Data analysis was performed using R software (version 3.0.1). Statistical significance was assessed by Pearson's chi-squared test or Fisher's exact test for categorical variables, and Student's t-test or Wilcoxon rank sum test for continuous variables. P-value less than 0.05 was considered as statistically significant.

Environmental Survey

As an environmental survey, we observed the working areas and process of food preparation, cooking and serving in the factory canteen as well as workers' rooms. Food samples from the canteen were collected and tested for thiamine by in-house method based on the Association of Analytical Communities (AOAC) 2011 to estimate thiamine intake of workers and compare with recommended dietary allowance (RDA) for adults.[11]

Results

Study among Myanmar Workers

After reviewing medical records in the hospitals and searched for suspect beriberi cases from November 2012 to July 2013, we identified four suspect cases who were Myanmar workers. Three of them died in the hospital. All four Myanmar cases were young men aged 18-27 years. Their onset dates were from November 2012 to March 2013. Symptoms included fever, numbness of extremities, weakness, leg pain, leg edema, dyspnea, chest pain and poor appetite. One case had rapid increase of pericardial effusion (Figure 1). One case recovered and survived after receiving thiamine supplements.

In the factory, we identified 13 suspect beriberi cases among 100 Myanmar workers by active case finding. Total of 17 suspect beriberi cases were identified, with case fatality rate of 17.6% and attack rate of 17%. Median age of suspect cases was 26 years (range 20-30 years) and male to female ratio was 3.3:1. Two of them had thiamine deficiency, with TPP blood levels of 97 nmol/L and 113 nmol/L.

All 17 suspect cases had signs and symptoms of both wet and dry beriberi (Figure 2). Symptoms of peripheral neuropathy included leg pain, numbness of extremities, weakness, burning sensation, inability to stand and tingling sensation. Symptoms of cardiomyopathy were leg edema, dyspnea, chest pain and chest discomfort. Gastrointestinal symptoms consisted of poor appetite, abdominal pain, vomiting and nausea.

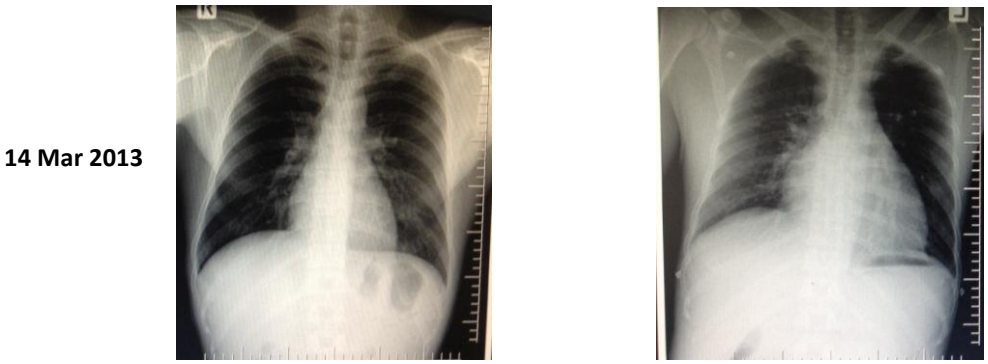

Figure 1. Chest X-rays of a worker with beriberi showing pericardial effusion in Factory A, Thailand, March 2013

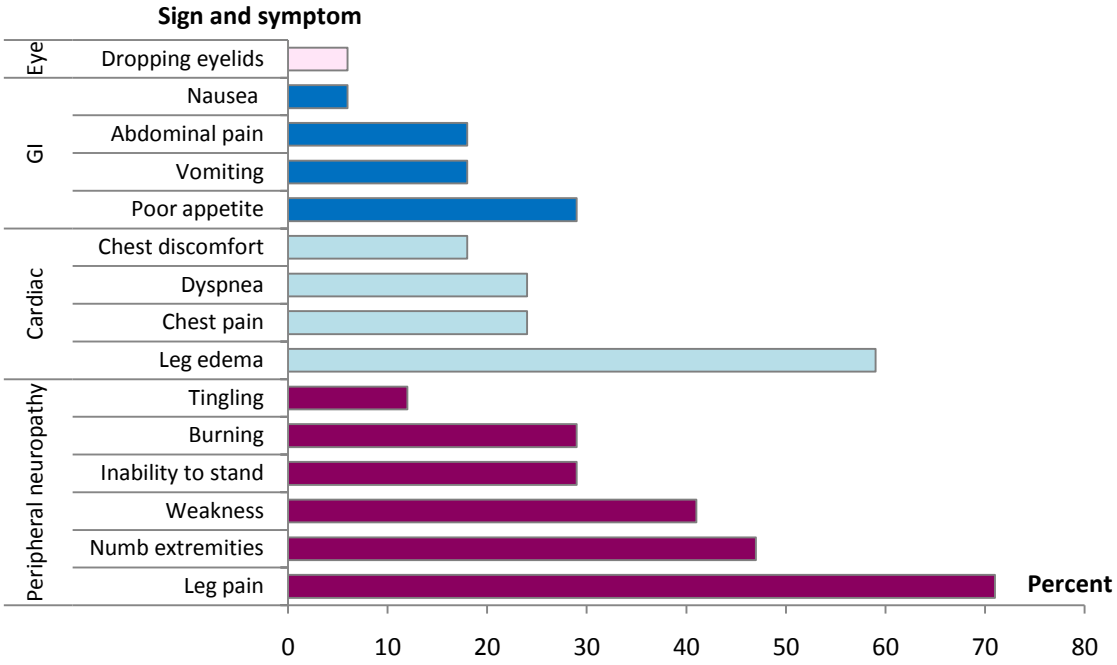

Figure 2. Signs and symptoms of suspect beriberi cases among Myanmar workers in Factory A, Thailand, November 2012 to July 2013 (n=17)

The first case's onset date was in November 2012. Number of new cases peaked in March 2013 and began to decrease in April when our team conducted the investigation. Out of total 17 suspect cases, one case aged 45 years old had symptoms for five years and thus, was not included in figure 3.

All Myanmar workers lived inside the factory. There were no significant differences between cases and non-cases with regard to age, gender, education, body mass index (BMI) and food or alcohol consumption (Table 1).

Study on Blood Thiamine Level

Epidemiological characteristics of 29 sampled workers were shown in table 2. Among 14 Myanmar workers sampled, one woman aged 38 years had thiamine deficiency and prevalence of thiamine deficiency among Myanmar workers was 7.1% (95% CI = 0-22.0). All 14 workers were Hindu and lived inside the factory.

Total 15 Thai workers sampled were Buddhists and lived in communities. Among them, four had thiamine deficiency and all were women, with median age of 54 years (range 45-65 years), and prevalence of thiamine deficiency of Thai workers was 26.7% (95% CI = 1.3-52.0). Median thiamine level of Thai was lower than that of Myanmar workers. However, the difference was not statistically significant (p-value = 0.29).

Environmental Survey

The Factory A was located in Phanom Sarakham District, Chachoengsao Province and was established in 2008. All Myanmar workers lived in small rooms surrounding the workplaces inside the factory while Thai workers lived in communities outside the factory. In the factory, Thai and Myanmar workers worked together in same production line.

From interview, workers reported higher workload during 2-3 months of the New Year period preceding

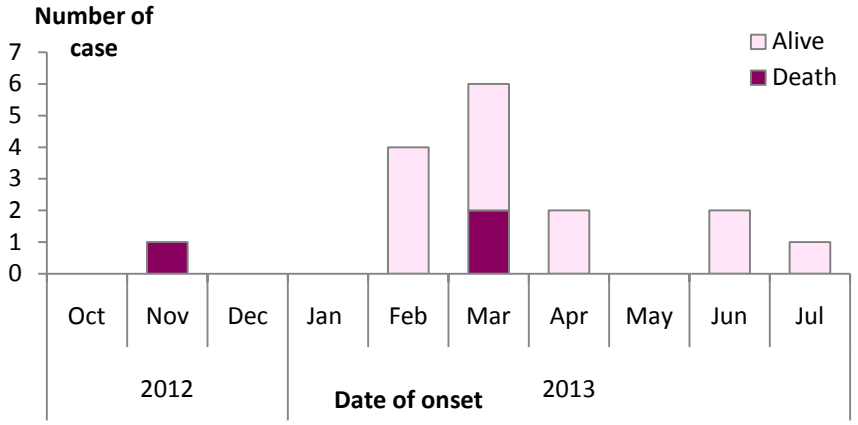

Figure 3. Suspect beriberi cases among Myanmar workers in Factory A, Thailand, November 2012 to July 2013 (n=16)

Table 1. Demographics, physical condition and consumption status of Myanmar workers in Factory A, Thailand, July 2013

Variable	Number of case (n=17)	Number of non-case (n=83)	Odds ratio (95% CI)	P-value
Median age (range)	26 years (20-30)	24 years (20-32)		0.46
Median year of education (range)	3.5 years (2.0-4.8)	4 years (2-6)		0.53
Gender (%)				
Male	13 (76.5)	50 (60.2)	2.1 (0.66-8.15)	
Female	4 (23.5)	33 (39.8)		
BMI (%)	*(n=13)*	*(n=83)*		
< 18.5	4 (30.8)	12 (14.5)	2.6 (0.50-11.35)	
≥ 18.5	9 (69.2)	71 (85.5)		
Median frequency of food consumption per week				
Chicken	3	3		0.72
Fermented fish	0	0		0.43
Bean	3	4		0.60
Betel nut	1	1		0.82
Tea or coffee	7	7		0.31
Alcohol consumption (%)	*(n=16)*	*(n=83)*		
Yes	3 (18.8)	14 (16.9)	1.1 (0.23-4.30)	
No	13 (81.3)	69 (83.1)		

Table 2. Epidemiological characteristics of workers tested for blood thiamine level in Factory A, Thailand, July 2013

Characteristic	Myanmar (n=14)	Thai (n=15)
Mean age in year (SD)*	28 (8)	47 (9)
BMI		
<18.5 (%)	2 (14.3)	0 (0)
18.5-25 (%)	10 (71.4)	10 (66.7)
≥25 (%)	2 (14.3)	5 (33.3)
Median thiamine level in nmol/L (IQR)	171 (145-213)	156 (114-196)
Median frequency of consuming thiamine-rich food weekly (range)		
Pork	0 (0,2)	3 (0,7)
Beef	0 (0,1)	0 (0,7)
Chicken	3 (1,5)	3 (0,7)
Bean	5 (1,7)	1 (0,7)
Median cost for food in Baht from November 2012 to July 2013 (range)	2,000 (1,500-6,000)	3,250 (2,000-6,000)
Number of person with alcohol consumption (%)	0	5 (33.3)
Number of person with inhalation of volatile glue (%)	3 (21.4)	7 (46.7)

** t-test, p-value <0.01*

the outbreak. Most of the Myanmar workers had no medical insurance while Thai workers had.

Most of Myanmar workers were young and had been working in Thailand for a few years. They went back to their hometowns during holidays or illness. They told that food in Myanmar was much cheaper than Thailand and they usually felt better after coming back from hometown. Myanmar workers usually bought food from the factory canteen or a mobile market nearby and prepared their meals at home. Both Myanmar workers and the canteen cooked food for a long time.

Milled white rice was the major portion of food consumed by both Thai and Myanmar workers. Common food sold in the canteen and the mobile market included vegetables, meat, eggs and fishes. Meals in the canteen were simple and consisted of roti (a type of flat bread which usually stuffed with boiled potato, vegetables, radish, cauliflower and/or paneer) and tea for breakfast, steamed rice with three food items (stir-fried vegetables, chicken with bean, potato soup and salad) for lunch, roti with tomato and tea for overtime workers in the evenings and steamed rice with 1-2 food items (stir-fried vegetables and vegetable soup) for dinner. Myanmar workers consumed similar recipes every week. All symptomatic cases were Hindu and abstained from eating meat three days per week.

Table 3. Thiamine levels of cooked food items in one day from canteen of Factory A, Thailand, 11 Jul 2013

Food item	Thiamine level (mg/100 gram)
Raw soybean	0.25
Roti	0.15
Stir-fried leave buds of rosella	0.13
Fried yard-long bean	0.10
Cabbage salad	0.08
Stir-fried bitter gourd	0.06
Stir-fried rosella	0.06
Stir-fried towel gourd	0.05
Tom yum soup	0.02

Cooked food items from the canteen were collected in July 2013 and tested for thiamine level (Table 3). Because we did not conduct the food consumption survey in this factory, we assumed that a worker ate 300 gram of rice and 100 gram of each food item per day. With the thiamine level of milled white rice as 0.08mg/100g[1], total thiamine intake calculated was 1.14 mg/person/day.

Discussion

We confirmed a cluster of beriberi among workers in Factory A during November 2012 to July 2013 in Chachoengsao Province of Thailand. Initial diagnosis for Myanmar hospitalized cases was done with no laboratory confirmation. Based on review from medical records of these cases, we found acute heart failure among young men while one of them recovered after receiving thiamine supplements. Additionally, laboratory results in our investigation showed seven cases with thiamine deficiency, including two cases identified from active case finding and five cases from blood thiamine study. Hence, although no history of death or beriberi case reported in this factory since 2008, existence of beriberi was confirmed in this factory after investigation.

Risk factors for thiamine deficiency were diet, body weight, physical activity, age, meal preparation and cooking, and anti-thiamine factors.[1] In this outbreak, thiamine deficiency might associate with risk factors such as poor diet, heavy physical activities and age. These risk factors were summarized in table 4.

Although our studies did not find any association with diet, results supported that this outbreak was related to dietary pattern: less meat dishes, high milled white rice and food with low thiamine. Workers consumed milled white rice, a high carbohydrate diet and also low thiamine level, which even led to more requirement of thiamine and caused thiamine deficiency. Moreover, the food processing of Myanmar workers reduced thiamine level in food due to long cooking time, which could lead to thiamine deficiency as well.

Besides, the investigation revealed effect of initial intervention on diet changes. The total thiamine intake that was in the RDA range of thiamine level for adults (1.1-1.2 mg daily)[1] showed that the first investigation had changed the workers' diet to rich thiamine foods such as soybean and affected total thiamine intake as well as the blood thiamine level among workers.

The second factor could be heavy physical activities due to high workload during previous months before the outbreak. This could explain suspect cases and deaths of Myanmar workers, especially from February to April 2013, based on low thiamine diet with heavy physical activities. This was also similar to a study about beriberi of Myanmar groups working in Thailand.[10]

The other factor could be the age. We found that prevalence of thiamine deficiency among older Thai

Table 4. Risk factors for thiamine deficiency among workers in Factory A, Thailand, July 2013

Risk factor	Reason
Diet	- Workers had few choices of food items because of their low salary.
	- Diets had poor thiamine, without meat, organ, poultry or whole grain rice.
	- Workers consumed high carbohydrate diet which led to higher requirement of thiamine.
Heavy physical activities	- They had higher workload during previous months before the outbreak
Medical condition	- Minimum requirements for dietary thiamine may increase with age, particularly for active individuals.[1]
	- Myanmar workers kept working until they had severe symptoms due to no health insurance.

women was higher than that of young Myanmar women. This was also compatible with a study by Oldham reported in WHO[1] that higher thiamine-calorie ratio was common for older people than young individuals.

The last factor was health insurance. As most of Myanmar workers had no medical insurance, they kept working until symptoms became severe and led to late diagnosis and treatment. With medical insurance of Thai workers from the Universal Coverage Scheme of Thailand[12,13], they might access to medical treatment even with mild symptoms. Thus, no severe case or death occurred among them although their prevalence of thiamine deficiency was higher than that of Myanmar workers.

Signs and symptoms of dry beriberi can vary a lot and are often difficult to be differentiated from other diseases. However, clinical symptoms and characteristics of hospitalized suspect cases in this outbreak suggested wet beriberi with leg edema and congestive heart failure. Hence, these signs and symptoms among young men could be a clue to look for thiamine deficiency in hospitals.

By combining rates of suspect cases and thiamine deficiency, we could assume high prevalence of thiamine deficiency among Myanmar and Thai workers in this factory. This might also suggest high prevalence of thiamine deficiency among Thai population in this region because of similar pattern of food consumption. These findings were also consistent with the Thai nutritional survey of construction and factory workers in 1996, which reported that those workers had high rates of biochemical, but not clinical, thiamine deficiency.[10] In addition, a survey on food consumption and nutrition in refugee camps along Thailand-Myanmar border from July to December 2003 found evidences of clinical and biochemical beriberi in all age groups (range 4.1-5.3 per 1,000 population).[10] Thus, further monitoring or enhancement of reporting system of beriberi was needed in this region.

Limitations

Because of time lapse between our investigation and beginning of the outbreak for about three months, Myanmar workers' diet had been changed as recommended by the first investigation team. This might explain why some symptomatic cases showed negative laboratory results and also cause information bias about signs and symptoms when we interviewed. Besides, with limited human resources and time, we could not conduct a dietary survey such as semi-quantitative food frequency or 24 hours recall for at least three days to be able to estimate and compare with RDA for thiamine.

Conclusion

There was a beriberi cluster among Myanmar workers in the factory. This outbreak was likely to be caused by long exposure to low thiamine food intake and heavy physical activities. The prevalence of thiamine deficiency among workers was high. Risk factors were likely to be poor diet and old age. Providing thiamine treatment and changing food items for thiamine rich diet stopped the outbreak.

Public Health Actions and Recommendations

We instructed factory workers how to identify symptoms of wet beriberi and provided health education about food with high level of B1.

Additionally, we recommended the hospitals for capacity building of clinicians on clinical diagnosis of cardiac beriberi and also providing effective health education on high level of B1 food to patients.

Finally, for the prevention and the improvement of the beriberi reporting system, we recommended

Provincial Health Office for monitoring of clinical manifestations of the factory workers and risk factors of thiamine deficiency.

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Trends and Characteristics of Occupational Injuries in Thailand, 2002-2010

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Abstract

Occupational injuries are important health problems in Thailand and cause significant health impacts on workers, in addition to economic loss. Data was obtained and analyzed from National Injury Surveillance (NIS) System for describing epidemiology of agricultural injuries and from Workmen's Compensation Fund (WCF) statistics for identifying trends and characteristics of injuries and deaths in industrial and business workers during the period of 2002-2010. Results from NIS showed that from 103,501 reported occupational injuries, 17,481 were related to agriculture and accounted for 16.9% of all injuries, with 96 deaths (fatality rate of 0.5 per 100 workers). Leading causes of agricultural injuries were struck by thrown or falling object (12.2%), contact with agricultural machinery (9.6%) and foreign body entering into eye or skin (8.0%). Most cases occurred in the afternoon during 1-6 pm (44.2%). The WCF statistics revealed that rates of injuries among industrial workers had decreased from 31.4 per 1,000 workers in 2002 to 16.5 per 1,000 workers in 2010. Leading causes of deaths were vehicle accident, fall from height and electrocution. Young workers aged 20-29 years old (46.4%) were more likely to get injured. The outcomes of this study could be used to develop guideline and strategy on surveillance system and prevention of occupational injuries in Thailand.

Key words: occupational injuries, agriculture, industry, business, Thailand

Introduction

Occupational injuries are important health problems among workers worldwide, especially in industrial and developing countries. Health effects of occupational injuries can vary significantly from acute or chronic pain, work loss, disability and financial loss to death. The highest proportion of injuries occurs among persons aged 15 to 59 years, the primary working ages. Globally, occupational-related injuries account for approximately 800,000 deaths and 100 million injuries, with estimated 14.5 billion USD spent annually for medical treatment.[1] These expenses can be considered as unjustified public health burden while many of injuries are preventable.

In 1997, the International Labor Organization (ILO) estimated burden of occupational accidents and injuries based on data gathered from selected ILO member states. Estimated rate for fatal occupational accidents was 14 per 100,000 workers, with 335,000 deaths annually.[1] Fatality rate in China was estimated as 10.5 per 100,000 workers while accident rate was 8,028 per 100,000 workers. There were 56 million of occupational accidents, with at least 3-days absence from work. In addition, over 48,000 workers in India died annually because of occupational accidents. About 970 people died every day because of occupational accidents. One fatal accident occurred over 760 occupational accidents that cause at least 3-days absence from work.[2]

In Thailand, National Statistical Office (NSO) reported that population in Thailand was approximately 63.5 million in 2009. Estimated number of workers was 37.1 million, including 13.8 million of formal workers (37.3%) and 23.3 million of informal workers (62.7%). Formal workers were people worked with official contract arrangement while informal workers were people worked outside their employer's workplace without official control.

Data from National Injury Surveillance (NIS) System of Thailand showed that work-related fatalities accounted for 2.8% of all reported fatalities from injuries during 2000-2004.[3] Most of the reported occupational injuries occurred at construction site (37.0%), followed by agricultural farm (18.9%). In addition, incidence rate of occupational injuries was 20.7 per 1,000 insured workers in 2008 based on social insurance data.[4] The government of Thailand issued a policy on occupational safety and health to promote labor protection in both formal and informal

sectors. The policy called for reduction and prevention of accidents among workers with a focus on workplace injuries. The master plan on Safework Thailand (2007-2011) aimed to reduce occupational accidents, decrease loss of valuable workers' lives and promote better quality of life for them.

Purposes of this study were to describe trends and characteristics of occupational injuries and deaths in Thailand between 2002 and 2010. Findings could be used to evaluate health impact of occupational injuries, plan compensation for workers by social security insurance system and guide in monitoring of workers' health.

Methods

A descriptive cross-sectional study was conducted to describe trends and characteristics of occupational injuries and deaths using data from the NIS system and the Workmen's Compensation Fund (WCF) in 2002-2010.

Number of workers recorded by the WCF represented a limited fraction of Thai workforce who worked in manufacturing sectors and registered under Social Security Office, Ministry of Labor and Social Welfare.[5] Although agricultural workers belonged to the largest group of workers (47.0%) in Thailand according to 2005 statistics from Bureau of Labor, they were not registered. Therefore, we used data from the NIS system to describe trends and characteristics of injuries among workers in agricultural sector and the WCF statistics for describing trends and characteristics of occupational injuries among industrial and business workers in Thailand.

A workplace injury was defined as an event of injury or accident occurred while working in industry or outside. Occupation injuries in this study included both cases and deaths.

The data sets were explored and cleaned to assure accuracy and completeness of individual records before analysis. Variables obtained from both databases included demographics, types of injury, behavior of work, organs injured, work time loss, places of accident, parts of body affected and others. Data management and analysis were done by EPI Info 2002.[6]

Results

The Bureau of Epidemiology, Ministry of Public Health routinely collected 104 variables on fatal and non-fatal injuries in Thailand. Severe cases of injuries and deaths were reported from 33 sentinel hospitals nationwide through the NIS. The WCF database, which was recorded by Ministry of Labor, provided information on injuries of all workers who had registered for compensation and had claimed for a workplace injury.

Data from NIS

The NIS reported 103,501 occupational injuries, including 1,080 deaths, from 2002 to 2010. Males made up 86% of all injured workers. There were 11,500 occupational injuries (range 7,891-17,311) annually, and average age of injured workers was 34.4 years (range 15-60 years).

Occupation with the greatest percentage of occupational injuries was labor (58.9%), followed by agricultural worker and farmer (16.9%). Common places of accidents were factory, construction site or hotel (39.1%), home (16.9%), farm or garden (16.8%) and road (10.8%) (Figure 1).

During 2002-2010, there were 17,481 agricultural injuries (16.9%) reported to NIS, resulting in 96 deaths (fatality rate 0.5 per 100 workers). Leading causes of occupational injuries in agriculture were struck by thrown or falling object (12.2%), contact with agricultural machinery (9.6%) and foreign body entering into eye or skin (8.0%) (Figure 2).

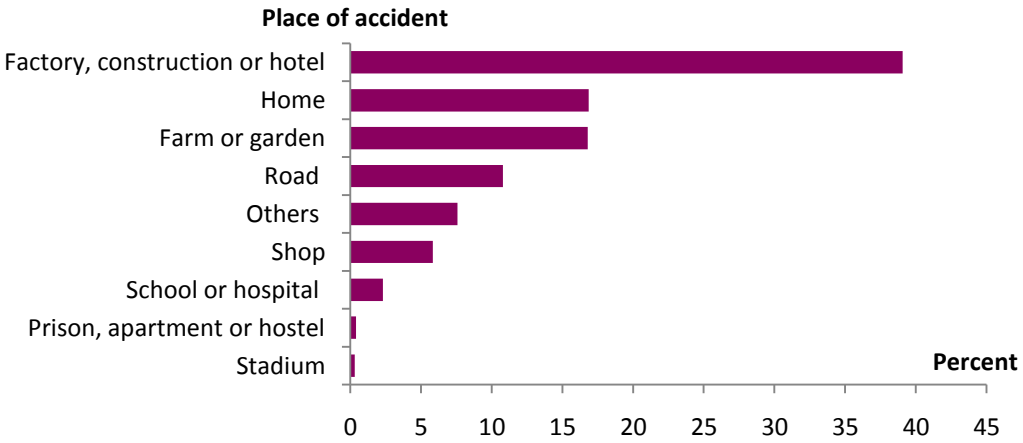

Figure 1. Occupational injuries by places of accident reported to the National Injury Surveillance System in Thailand, 2002-2010 (n=103,501)

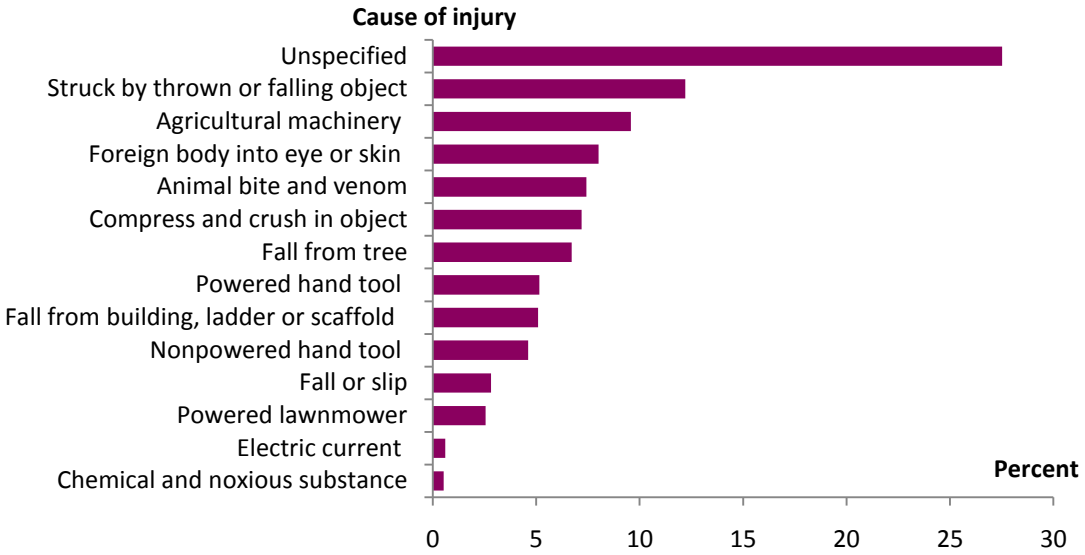

Figure 2. Causes of occupational injuries among agricultural workers reported to the National Injury Surveillance System in Thailand, 2002-2010 (n=17,481)

Although occupational injuries occurred anytime during working hours, most cases took place during 1-6 pm (44.2%). Common injured parts of body were extremities such as leg, arm and finger (53.1%), followed by skin (20.0%), eye and part of face (7.3%), and head and neck (6.7%). Severe cases were due to electrocution (11.2%) and fall from height (36.3%).

Data from WCF

Data from the WCF statistics were used to characterize trends and types of injuries among workers in manufacturing and business groups from 2002 to 2010. Average number of workers covered by the WCF was 8,100,183 and the system received 191,586 claims due to occupational injuries (23.7 per 1,000 workers) annually.

From 2002 to 2010, annual number of occupational injuries reported was nearly 190,000 and 800 deaths per year. Trends of non-fatality and fatality rates of occupational injuries had decreased consistently every year from 2002 to 2010. Injury rates, including deaths, decreased from 31.4 per 1,000 workers in 2002 to 16.5 per 1,000 workers in 2010. Fatality rate was also markedly decreased from 11.8 to 6.5 per 100,000 workers, except in the year 2005 that was slightly increased.

Table 1 revealed degree of work loss, disability and deaths from the injuries. Up to 72.4% of injured workers were absent from work three days or less, and only 0.4% were fatal or permanently disabled.

Table 1. Occupational injuries by degree of loss and death reported to the Workmen's Compensation Fund in Thailand, 2002-2010

Year	Number (Percent)					Total
	Death	Permanent disability	Permanent partial disability	≥ 3 days absence	< 3 days absence	
2002	650 (0.3)	14 (< 0.1)	3,424 (1.8)	49,012 (25.7)	137,879 (72.2)	190,979
2003	787 (0.4)	17 (< 0.1)	3,821 (1.8)	52,364 (24.9)	153,684 (72.9)	210,673
2004	861 (0.4)	23 (< 0.1)	3,775 (1.8)	52,893 (24.5)	157,982 (73.3)	215,534
2005	1,444 (0.7)	19 (< 0.1)	3,425 (1.6)	53,641 (25.0)	155,706 (72.7)	214,235
2006	808 (0.4)	21 (< 0.1)	3,413 (1.7)	51,901 (25.4)	148,114 (72.5)	204,257
2007	741 (0.4)	16 (< 0.1)	3,259 (1.6)	50,525 (25.4)	144,111 (72.5)	198,652
2008	613 (0.3)	15 (< 0.1)	3,096 (1.8)	45,719 (25.9)	127,059 (72.0)	176,502
2009	579 (0.4)	8 (< 0.1)	2,383 (1.6)	39,850 (26.7)	106,616 (71.3)	149,436
2010	619 (0.4)	11 (< 0.1)	2,149 (1.5)	39,919 (27.2)	103,813 (70.9)	146,511
Total	7,102 (0.4)	144 (< 0.1)	28,745 (1.7)	435,824 (25.5)	1,234,964 (72.4)	1,706,779

Common types of occupational injuries by physicians' diagnosis from 2004 to 2010 were puncture and penetrating wound, dislocation or displacement of bone, abrasion or laceration, and bone fracture. Most types of injuries decreased, except bone fracture (Table 2).

Finger (29.4%) and eye (20.6%) were the most commonly affected organs in occupational injuries among industrial and business groups (Figure 3). Majority of occupational deaths had injury in multiple organs (84.0%), head (7.9%), neck and back (1.8%) and chest (1.6%).

Table 2. Occupational injuries by physician diagnosis reported to the Workmen's Compensation Fund in Thailand, 2004-2010

Nature of injury	Number (Percent)						
	2004	2005	2006	2007	2008	2009	2010
Bone fracture	15,340 (7.1)	15,464 (7.2)	15,654 (7.7)	15,577 (7.8)	14,822 (8.4)	12,932 (8.7)	13,116 (9.0)
Dislocation or displacement of bone	30,895 (14.3)	33,657 (15.7)	32,758 (16.0)	33,240 (16.7)	29,769 (16.9)	27,453 (18.4)	27,158 (18.5)
Concussion and crushing	844 (0.4)	614 (0.3)	540 (0.3)	660 (0.3)	678 (0.4)	625 (0.4)	582 (0.4)
Amputation	3,165 (1.5)	3,105 (1.5)	2,790 (1.4)	2,737 (1.4)	2,662 (1.5)	2,159 (1.4)	2,361 (1.6)
Puncture and penetrating wound	94,581 (43.9)	92,857 (43.3)	87,732 (43.0)	83,965 (42.3)	73,167 (41.5)	61,517 (41.2)	60,129 (41.0)
Abrasion or laceration wound	34,581 (16.0)	33,715 (15.7)	30,135 (14.8)	29,220 (14.7)	26,502 (15.0)	21,117 (14.1)	20,582 (14.1)
Contusion and bruise wound	11,986 (5.6)	11,044 (5.2)	11,439 (5.6)	10,640 (5.4)	9,397 (5.3)	7,454 (5.0)	7,045 (4.8)
Burn	16,732 (7.8)	15,687 (7.3)	15,546 (7.6)	15,383 (7.7)	13,444 (7.6)	11,044 (7.4)	10,827 (7.4)
Chemical burn	908 (0.4)	892 (0.4)	1,288 (0.6)	869 (0.4)	772 (0.4)	729 (0.5)	830 (0.6)
Freezing and heat exposure	1,707 (0.8)	1,802 (0.8)	1,716 (0.8)	1,926 (1.0)	1,903 (1.1)	1,426 (1.0)	1,170 (0.8)
Asphyxiation	33 (< 0.1)	24 (< 0.1)	31 (< 0.1)	26 (< 0.1)	19 (< 0.1)	28 (< 0.1)	15 (< 0.1)
Electric Shock	675 (0.3)	687 (0.3)	748 (0.4)	784 (0.4)	645 (0.4)	582 (0.4)	555 (0.4)
Light and radiation	2,883 (1.4)	2,896 (1.4)	2,648 (1.3)	2,192 (1.1)	1,629 (0.9)	1,337 (0.9)	1,082 (0.7)
Multiple injuries	96 (< 0.1)	44 (< 0.1)	149 (0.1)	274 (0.1)	243 (0.1)	204 (0.1)	203 (0.1)
Others	1,108 (0.5)	1,747 (0.8)	1,083 (0.5)	1,159 (0.6)	850 (0.5)	829 (0.6)	856 (0.6)

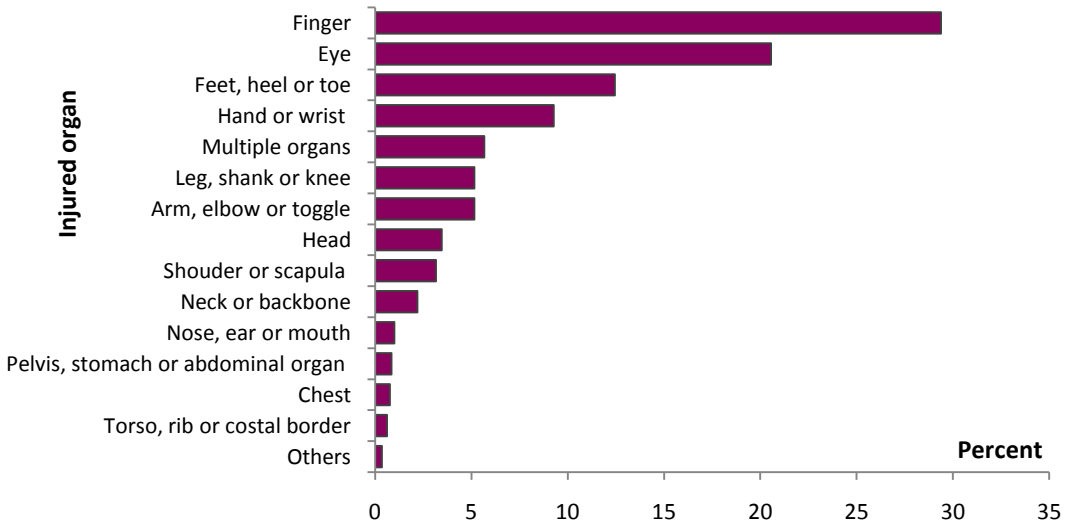

Figure 3. Occupational injuries by injured organs reported to the Workmen's Compensation Fund in Thailand, 2002-2010

Causes of occupational injuries in industrial and business groups were significantly different from agricultural group reported in the NIS system. The leading causes of injuries ranged from cut or penetrated by sharp material (24.0%), thrown or crashed in object (16.7%), foreign matter into eye (16.6%) and falling object (13.6%). However, vehicle-related accident was the most common cause of death, which accounted for 43.9% of all fatalities, followed by fall from height (12.1%) and electrocution (11.7%) (Figure 4).

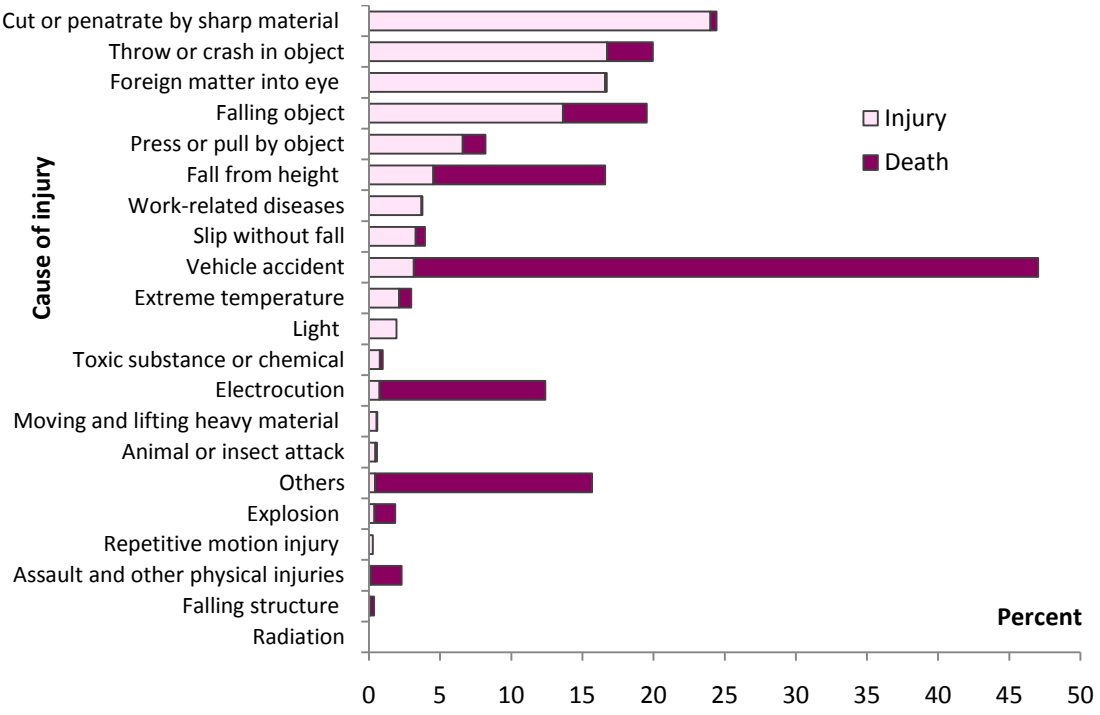

Figure 4. Causes of occupational injuries reported to the Workmen's Compensation Fund in Thailand, 2002-2010

Table 3. Occupational Injuries by age groups reported to the Workmen's Compensation Fund in Thailand, 2002-2010

Age (year)	Number (rate per 1,000 workers)								
	2002	2003	2004	2005	2004	2007	2008	2009	2010
< 15	6 (< 0.1)	-	3 (< 0.1)	3 (< 0.1)	-	3 (< 0.1)	-	1 (< 0.1)	2 (< 0.1)
15-19	14,963 (2.9)	16,185 (2.2)	15,824 (2.1)	14,523 (1.8)	12,654 (1.5)	11,645 (1.3)	10,342 (1.2)	7,737 (0.9)	8,111 (0.9)
20-24	48,764 (7.5)	52,952 (7.3)	52,287 (6.8)	48,209 (6.0)	42,790 (5.1)	37,946 (4.4)	31,617 (3.6)	23,799 (2.8)	23,116 (2.6)
25-29	47,368 (7.2)	51,448 (7.1)	52,862 (6.9)	53,039 (6.6)	50,473 (6.0)	47,015 (5.4)	40,520 (4.6)	32,728 (3.8)	36,652 (4.2)
30-34	32,434 (5.0)	35,611 (4.9)	36,465 (4.8)	37,039 (4.6)	36,898 (4.4)	37,233 (4.3)	33,180 (3.8)	28,907 (3.4)	22,254 (2.5)
35-39	21,229 (3.3)	24,154 (3.4)	25,511 (3.3)	26,086 (3.2)	25,935 (3.1)	26,871 (3.1)	24,625 (2.8)	21,741 (2.5)	21,556 (2.4)
40-44	12,921 (2.0)	14,812 (2.1)	15,879 (2.1)	16,915 (2.1)	16,930 (2.0)	17,772 (2.0)	16,677 (1.9)	15,611 (1.8)	15,440 (1.8)
45-49	7,379 (1.1)	8,788 (1.2)	9,347 (1.2)	10,333 (1.3)	10,161 (1.2)	10,883 (1.3)	10,451 (1.2)	9,944 (1.2)	10,192 (1.2)
50-54	3,822 (0.6)	4,408 (0.6)	4,756 (0.6)	5,260 (0.7)	5,346 (0.6)	5,956 (0.7)	5,852 (0.7)	5,765 (0.7)	5,789 (0.7)
55-59	1,413 (0.2)	1,615 (0.2)	1,892 (0.3)	2,099 (0.3)	2,301 (0.3)	2,521 (0.3)	2,488 (0.3)	2,409 (0.3)	2,580 (0.3)
≥ 60	680 (0.1)	687 (0.1)	708 (0.9)	729 (0.1)	769 (0.1)	807 (0.1)	750 (0.1)	794 (0.1)	819 (0.1)

Overall, the highest proportion of workers with occupational injuries aged between 20 and 29 years (46.4%) while rates of occupational injuries declined in all age groups, except 50-54 years and 55-59 years (Table 3).

As for the occupational injuries classified by the national industrial classification from Ministry of Labor, Thailand, the highest numbers of injuries from 2004 to 2010 were manufacturing of metal product (18.0%) and trade (11.9%), with mostly decrease in trends of injured workers. Rate of occupational injuries slightly decreased from 2004 (16.6%) to 2010 (11.3%) and rates of injuries in metal production decreased from 5.1 to 2.9 per 1,000 workers as well (Table 4). Occupations with high percent of fatality were observed in trade (16.5%), transportation and communication (16.0%), and construction (15.2%).

Discussion

This descriptive study identified many interesting characteristics and trends of occupational injuries in Thailand from 2002 to 2010. The study results revealed a significant proportion (16.9%) of agricultural injuries from all occupational injuries reported to the NIS during 2002-2010.

The data showed the leading causes of injuries in agricultures. Severe cases within this group occurred from electrocution and fall from height. This was a unique pattern and different from previous studies carried out in United States. Agricultural fatality rate in the United States was 22.0 per 100,000 workers through 1990s. Tractors-related injuries were the leading cause of deaths accounted for at least 300 fatalities each year and 16.6 per 100 injuries between 1998 and 2002.[7]

Table 4. Occupational Injuries by national industrial classification reported to the Workmen's Compensation Fund in Thailand, 2004-2010 (n=1,302,127)

Industrial classification	Number (Percent)							Total
	2004	2005	2006	2007	2008	2009	2010	
Metal products	39,300 (18.2)	38,542 (18.0)	38,255 (18.7)	35,573 (17.9)	32,296 (18.3)	25,634 (17.5)	25,939 (17.7)	235,539 (18.1)
Trade	21,624 (10.0)	22,992 (10.7)	22,247 (10.9)	23,194 (11.7)	20,660 (11.7)	18,818 (12.9)	18,038 (12.3)	147,573 (11.3)
Other types of business	18,743 (8.7)	20,963 (9.8)	19,978 (9.8)	21,057 (10.6)	19,370 (11.0)	17,044 (11.6)	16,649 (11.4)	133,804 (10.3)
Construction	18,982 (8.8)	20,979 (9.8)	20,201 (9.9)	21,021 (10.6)	17,101 (9.7)	15,184 (10.4)	12,919 (8.8)	126,387 (9.7)
Chemical products and petroleum	18,887 (8.8)	17,587 (8.2)	16,936 (8.3)	16,517 (8.3)	14,550 (8.2)	12,278 (8.4)	12,315 (8.4)	109,070 (8.4)
Manufacturing of foods and beverages	16,518 (7.7)	15,882 (7.4)	15,226 (7.5)	14,931 (7.5)	13,710 (7.8)	12,880 (8.8)	12,571 (8.6)	101,718 (7.8)
Assembling and manufacturing of vehicles	15,951 (7.4)	16,671 (7.8)	15,198 (7.4)	14,028 (7.1)	13,037 (7.4)	9,855 (6.7)	11,486 (7.8)	96,226 (7.4)
Manufacturing of textiles and accessories	16,147 (7.5)	14,386 (6.7)	13,676 (6.7)	11,895 (6.0)	10,324 (5.8)	8,326 (5.7)	7,583 (5.2)	82,337 (6.3)
Manufacturing of basic metals	13,766 (6.4)	13,080 (6.1)	12,358 (6.1)	11,719 (5.9)	10,639 (6.0)	8,184 (5.6)	8,061 (5.5)	77,807 (6.0)
Forestry and wood products	13,403 (6.2)	11,501 (5.4)	10,008 (4.9)	8,706 (4.4)	7,087 (4.0)	5,838 (4.0)	5,637 (3.8)	62,180 (4.8)
Transportation and communication	6,132 (2.8)	6,489 (3.0)	6,096 (3.0)	6,017 (3.0)	5,689 (3.2)	2,094 (1.4)	5,061 (3.5)	37,578 (2.9)
Products from non-metallic minerals	5,726 (2.7)	5,673 (2.6)	5,207 (2.5)	4,912 (2.5)	4,171 (2.4)	3,530 (2.4)	3,625 (2.5)	32,844 (2.5)
Paper products and printing	5,429 (2.5)	5,115 (2.4)	4,660 (2.3)	4,924 (2.5)	4,354 (2.5)	3,763 (2.6)	3,600 (2.5)	31,845 (2.4)
Other manufacturing industries	3,058 (1.4)	2,788 (1.3)	2,604 (1.3)	2,664 (1.3)	2,201 (1.2)	1,782 (1.2)	1,844 (1.3)	16,941 (1.3)
Mining survey	1,240 (0.6)	1,072 (0.5)	1,073 (0.5)	978 (0.5)	775 (0.4)	722 (0.5)	723 (0.5)	6,583 (0.5)
Public utilities	628 (0.3)	515 (0.2)	534 (0.3)	516 (0.3)	538 (0.3)	504 (0.3)	460 (0.3)	3,695 (0.3)

Both databases on occupational injuries, NIS and WCF, complemented each other in identifying trends and patterns of occupational injuries in Thailand. The WCF statistics revealed that rates of injuries among industrial workers had decreased from 31.4 per 1,000 workers in 2002 to 16.5 per 1,000 workers in 2010. Rates of annual occupational injuries among small-scale industrial workers in Zimbabwe and Nigeria were 131 and 22 per 1,000 workers respectively.[8,9]

The most common causes of injuries included cut or penetrated by sharp material and thrown or crashed in object while causes of deaths were due to vehicle accident and fall from height. The findings were similar to a previous study in Qatar from 2006 to 2010 which stated leading causes of injuries were road traffic accidents (21.2%), injury by industrial machinery (16.4%) and accidents in construction (15.5%).[10]

After reviewing natures of injuries, workers involved with machine operation, material handling and unskilled workers were more prone to get injured. Workers who worked in manufacturing of metal products and trade had increased risk of injury in workplaces.

Majority of all injured workers in this study were males (86%). Reports from France and China showed that men had higher rate of work-related injuries than women.[11,12] However, a study conducted in Addis Ababa of Ethiopia reported that gender had no association with prevalence of occupational injuries.[13,14]

Findings of this study demonstrated high frequency of occupational injuries among workers aged between 20 and 34 years, indicating possible high impact on dependent family members if the injured workers developed permanent disability or death. In the United States, the Bureau of Labor Statistics collects data on annual census of fatal occupational injuries and reports number of fatal occupational injuries gathered from 50 states and the District of Columbia. During 2005, the highest proportion of workplace deaths (44%) was among workers aged 35-54 years.[15] Similar observation was also reported by other studies that young workers tend to have higher rate of occupational injuries due to lack of information, low experience and no training on safety measures.[5,16,17] Thus, young workers should be trained before starting a new job. Moreover, as we found that older workers aged between 50 and 59 years had increased rate of occupational injuries, restriction of people older than 50 years to work in industries with heavy workload or limiting working duration might prevent injuries in old workers.

Both databases did not collect all needed data. The NIS system was operated in only 33 sentinel hospitals and data did not available in over half of the total 77 provinces. While data from the WCF statistics did not include agricultural workers in social insurance scheme and compensation fund, it was necessary to seek other sources of data to explain trend of injuries among agricultural workers which actually was the highest percentage of workforce in Thailand.

Information on occupational injuries is vital to identify work-related injuries and high risk groups for intervention measures. Surveillance systems should be developed to specifically collect data on agricultural workers, construction and others, including migrant and seasonal workers. Appropriate strategies, including regulations and prevention measures, should be developed based on findings obtained from the surveillance information.

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Evaluation of Three Main Tuberculosis Case Reporting Systems in Satun Province, Thailand, 2011

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Abstract

Three main tuberculosis (TB) reporting systems were operating in Thailand: notifiable disease surveillance (R506), TB registration and control in Bureau of Tuberculosis (BTB) and TB report for reimbursement in National Health Security Office (NHSO). A cross-sectional study was conducted in Satun Province in July 2011 to determine whether the three systems responded well to the objectives of TB surveillance. Patients diagnosed with TB and received anti-TB drugs at least once in 2010 from three hospitals were compared with TB cases reported in three systems. In the hospitals, 170 TB cases, including 95 new smear positive pulmonary TB cases, were reviewed. Coverage and positive predictive value were 73% and 83% for R506, 87% and 100% for BTB, and 79% and 99% for NHSO respectively. Success rate (82%) of all cases was lower than that was reported in BTB (96%). Median duration from diagnosis to reporting in R506, BTB and NHSO were six, 61 and two days respectively. All systems had sufficient budget, human resources and regular training. In addition, all systems had good capacity to achieve the major objectives of TB surveillance and their specific objectives. However, the systems had total 295 variables which resulted in high workload for reporting. Integrating three systems as one national TB reporting system was recommended to improve coverage, timeliness and success rate.

Key words: tuberculosis, surveillance, evaluation, Thailand

Introduction

Tuberculosis (TB) is a chronic and potentially lethal infectious disease caused by *Mycobacterium tuberculosis*, with over nine million new infections and 1.7 million deaths every year, including 230,000 HIV-associated TB cases.[1,2] Surveillance is a critical component for successful TB control.[3-5] Major aims and objectives of TB surveillance were generally designed to reduce burden of mortality and morbidity from TB by identification and treatment of cases as well as management of contacts. A well developed surveillance system could also help to detect outbreaks and evaluate treatment and prevention programs.[4-7]

There were three main TB reporting systems in Thailand conducted by Bureau of Epidemiology (BOE), Bureau of Tuberculosis (BTB) and National Health Security Office (NHSO) (Figure 1).[8,9] TB surveillance conducted by BOE was based on the notifiable diseases surveillance system (R506) which reported data on the Morbidity Notification Card 506. Only new patients with acid-fast bacilli (AFB) positive on a sputum smear were reported by the R506 system.[9] The BTB had the national registration system with its own reporting forms for TB treatment and control.[8] The TB reporting system in NHSO collected data for reimbursement of TB diagnosis and treatment in Universal Coverage Scheme since 2007.[9]

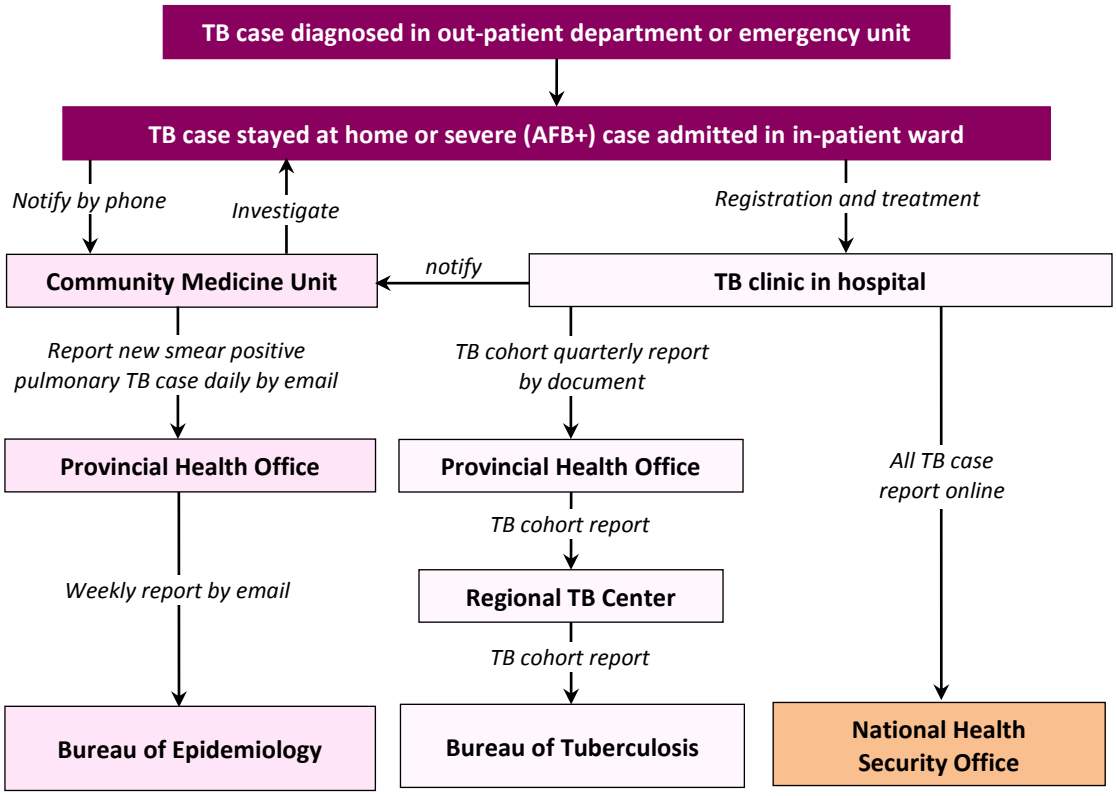

Figure 1. Workflow of 3 tuberculosis reporting systems in Satun Province, Thailand, 2010

The TB surveillance systems should be evaluated periodically to ensure the systems meet their objectives of TB surveillance, and improve quality, efficiency and usefulness.[6,9,10] Moreover, these systems had never been simultaneously evaluated. A cross-sectional study was conducted in Satun Province in July 2011 to determine whether the systems responded well to the objectives of TB surveillance and fulfilled their specific objectives. This study would be meaningful in improving TB surveillance and control in Thailand and also in other countries with similar situation.

Methods

Study Sites

This study was conducted in Satun Province of Thailand in July 2011. Satun Province is located in the southern part of Thailand and close to the Thailand-Malaysia border with vibrant population and migration. Hospitals with scales of 30, 60 and 90 beds and new TB cases reported in R506 during 2010 were included in this study. Three hospitals with the highest number of TB cases in 2010 were selected from total six hospitals in the province, including Satun Provincial Hospital, La-ngu District Hospital and Khuan Don District Hospital.

Case Definition

A TB case was a patient diagnosed as TB by a physician and received anti-TB treatment at least one time in one of the studied hospitals during 2010.[12,13] Exclusion criteria included TB cases referred to another hospital, diagnosis changed from TB to other diseases, foreigners or prisoners with TB, and contacts who received anti-TB drugs for preventive treatment. A new smear positive pulmonary (new M+) TB case was a new pulmonary TB patient with at least one time smear positive in three different sputum samples for acid-fast bacilli (AFB) testing during the first month after diagnosis.

Sample Size

The World Health Organization (WHO) reported that case detection rate (CDR), the proportion of notified incident cases, for all TB cases in Thailand was estimated as 69%[13] which was used to estimate sample size for sensitivity of case reporting. As no estimates were available for positive predictive value (PPV), 50% was used to obtain the largest sample size.[14] The sample size was calculated to estimate sensitivity and PVP within 10% of the true value, using 95% confidence interval (95% CI) and α as 0.05. Total number of cases reported by R506 system in 2010 was 100, which was considered as the population for PVP, and population for sensitivity was 145 (100/0.69).

Quantitative Data Collection

Medical records of TB cases in three hospitals were reviewed and compared with data from the reporting

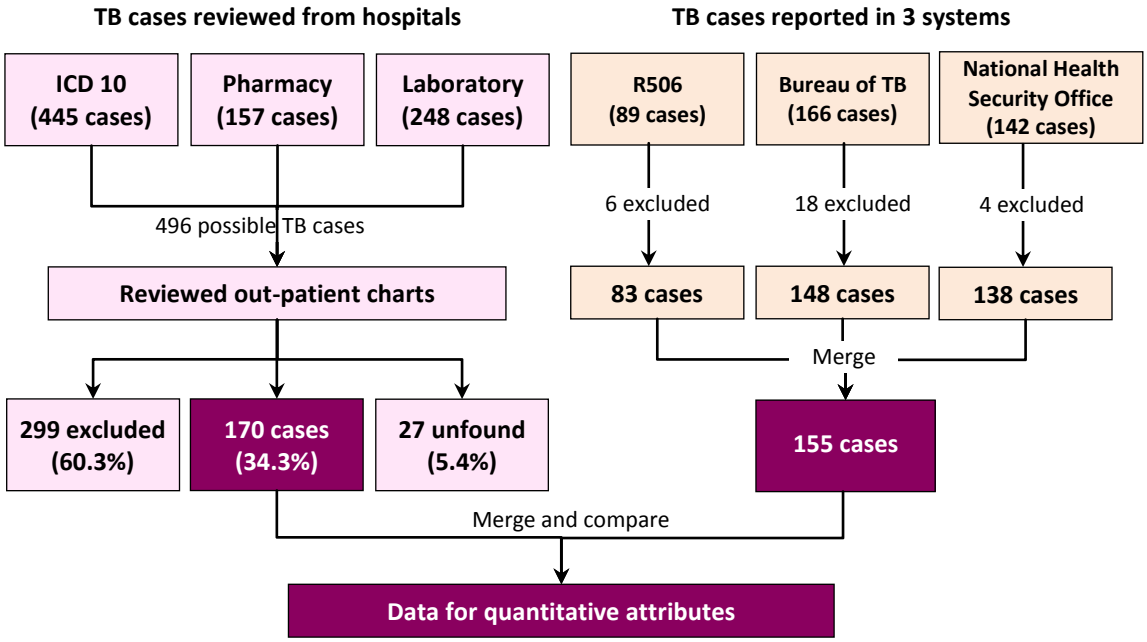

Figure 2. Tuberculosis cases reviewed from 3 hospitals and reported in 3 reporting systems, Satun Province, Thailand, 2010

systems (Figure 2). A possible TB case was a patient diagnosed as TB in one of the three hospitals during 2010 and met one of the following conditions: 1) 10th revision of the international classification of diseases (ICD-10) code of A15 (respiratory TB confirmed by bacteriologically and histologically), A16 (respiratory TB, but not confirmed bacteriologically or histologically), A17 (TB of nervous system), A18 (TB of other organs), A19 (miliary TB), B20.0 (HIV disease resulting in TB) or B90 (sequelae of TB);[11] 2) a patient recorded for receiving anti-TB drugs in logbook of hospital pharmacy; 3) a patient recorded as positive sputum smear in logbook of hospital laboratory. Then, possible cases were searched from ICD-10 data, pharmacy and laboratory logbook (Figure 2), and matched with charts from out-patient department (OPD) by hospital number to determine whether they met the TB case definitions.

Data reported by the hospitals in 2010 were also collected, including cases reported in R506, NHSO, and TB03 form, TB07 quarterly form, TB07/1 laboratory result form and TB08 treatment outcome form of BTB.

Qualitative Data Collection

Total 31 staff from central, regional, provincial health office (PHO), district health offices (DHO), health center and hospitals was interviewed by semi-structured questionnaires, including five policy makers, one physician, three laboratory officers, three pharmacists, 14 reporting officers, two medical statisticians and three public health officers.

Indicators for Qualitative and Quantitative Attributes

Workflow and operation of three TB reporting systems in Satun Province were assessed. Data quality, coverage, PPV, multi-drug resistance TB (MDR-TB) and treatment outcome were evaluated by analyzing data reviewed from the hospitals and the reporting systems (Table 1).[15-17] Case notification rate in a district was calculated as dividing number of cases reviewed from a hospital by number of mid-year population in district that the hospital was located. In addition, capacity and support, TB screening and contact tracing, simplicity, stability and usefulness were summarized from the interview (Table 1).[7,17]

Statistical Analyses

Quantitative data was transformed into a computerized data set. The Kruskal-Wallis rank test was performed to compare timeliness of report in the hospitals and 2-sided p-values were reported with a significance level of less than 0.05.

Results

Overview of TB Reporting Systems

Figure 1 showed how a patient diagnosed with TB was reported to R506, BTB or NHSO systems. As for R506, information of new M+ cases with 35 variables was reported to PHO by email, and much effort was needed to summarize the data every week and check for duplicated records. In BTB, a reporting center with physician, nurse, pharmacist and assistant was in TB clinic. Forms used in BTB included TB01 and TB03 with 39 variables for case registration, TB07

Table 1. Main attributes used for evaluating 3 tuberculosis reporting systems in Satun Province, Thailand, 2010

No.	Attribute	Definition	R506	Bureau of TB	National Health Security Office
	Qualitative Attributes				
1.	Description of system	Objective, flow and operation of each system	✓	✓	✓
2.	Simplicity	Structure and ease of operating each system, considering amount and type of data, and methods of collecting, reporting, analyzing and disseminating data	✓	✓	✓
3.	Stability	Reliability (the ability to collect, manage and provide data properly without failure) and availability (the ability to operate) of each system	✓	✓	✓
4.	Identification and management of contact	Identification, tracing and managing contacts of pulmonary TB cases in surveillance	✓		
5.	Program capacity and support	Ability and support (organization, staffing, resources and facilities) to carry out the core components of each system	✓	✓	✓
6.	Usefulness	The real "action taken" as a result of the data obtained from 3 systems	✓	✓	✓
	Quantitative Attributes				
7.	Data quality				
	- Completeness	Completeness of key variables	✓	✓	✓
	- Duplication	Proportion of duplicated cases in systems	✓	✓	
	- Accuracy	Accuracy of age, type of patient and treatment outcome in systems	✓	✓	
8.	Coverage				
	- Coverage of all TB cases	Proportion of all TB cases reported in each system		✓	✓
	- Coverage of new smear positive pulmonary (new M+) TB cases	Proportion of new M+ TB cases reported in R506	✓		
9.	Positive predictive value (PPV)	Proportion of cases that meet the TB case definition of this study among reported cases in each system	✓	✓	✓
10.	Timeliness				
	- Timeliness of report	Time interval between diagnosis and reporting to each system	✓	✓	✓
	- Timeliness of treatment	Time interval between diagnosis and first anti-TB treatment in Bureau of TB and National Health Security Office		✓	✓
11.	Treatment effects				
	- Conversion rate	Proportion of AFB negative at 2nd month of treatment among new M+ TB cases[12, 20]		✓	
	- Success rate	Proportion of cases cured or completed treatment[12]		✓	

with 37 variables for summarizing data based on TB03, TB07/1 with 40 variables for reporting sputum conversion rate after TB07 for six months, TB08 with 40 variables for reporting treatment outcome after TB07 for one year. The regional TB center gave feedback to PHO which also provided it again to TB clinic in the hospitals, based on the data from BTB. For NHSO, clinicians in Satun Hospital and Khuan Don Hospital reported data online with 104 variables. The central office of NHSO reimbursed the hospitals

every three months according to the data reported. In addition, regional NHSO could extract summary data from the central office quarterly or annually.

TB Screening and Contact Tracing

According to the interviews, policy makers placed a high priority on TB case screening for surveillance and control. Patients diagnosed of diabetes, chronic obstructive pulmonary disease (COPD), asthma or HIV with cough more than two weeks and patients with hemoptysis or productive cough were routinely screened by sputum smear for AFB and/or chest X-ray in the hospitals. The TB screening campaign for migrant workers and Thai residents in Satun was conducted once in 2010.

Data from R506 could be used for contact tracing. Active contact tracing was conducted by DHO and health centers with criteria by age groups. Investigation form was used for contact identification in Satun and Khuan Don Hospitals. However, data collection and analysis of contact tracing were not systematic.

Reviewing and Reporting of Cases

A total of 496 possible TB cases were identified from the hospitals, and 170 cases (34.3%) met the definition of TB case, including 95 new M+ cases (Figure 2). Total 299 possible cases were excluded, including patients diagnosed before or after 2010 (57.2%), suspected TB patients without AFB positive results (15.7%) and cases referred to hospitals in other district or province (13.4%). Case notification rate of all TB cases and new M+ in three districts during 2010 were 95 and 53 per 100,000 population respectively. Total 83, 148 and 138 cases were reported in R506, BTB and NHSO respectively (Figure 2).

Quality of Data

Completeness of data in three systems were 100% for key variables which included name, gender, age, address, diagnosis date, reporting date and type of patient. In NHSO, it was also 100% reporting for the variables of number, gender and registration date. However, completeness of some variables reduced with time course of disease, including 99% for diagnosis date, 89% for treatment date, 58% for sputum conversion result and 56% for treatment outcome. Although R506 had one duplicated case, TB03 in BTB had none. Duplication in NHSO could not be checked as there was no patient's name in the report. Compared to data reviewed from the hospitals, accuracy of age, type of patient and treatment outcome in BTB were 87.8% (129/147), 91.8% (134/146) and 83.3% (115/138) respectively while accuracy of age in R506 was 85.2% (69/81).

Median duration from diagnosis to reporting in R506 was significantly different in the hospitals. Satun Hospital had the shortest duration with three days, followed by La-ngu Hospital and Khuan Don Hospital with 52 and 55 days respectively (Table 2). However, Satun Hospital needed longer time (10 days) than the other two hospitals to report to BTB. Although timeliness of reporting was not significantly different in NHSO, this system took a long time to input data due to total 104 variables and low internet speed.

Coverage and PPV

Coverage of all TB cases in the merged database of three systems was 88.8% (151/170). Coverage of new M+ cases in R506 was 72.6% (69/95) while coverage of all cases was 87.1% (148/170) in BTB and 79.4% (135/170) in NHSO. PPV of all cases was 98.8% (82/83) in R506, 100% (148/148) in BTB and 97.8% (135/138) in NHSO. However, PPV for new M+ case in R506 was 83.1% (69/83).

Culture and Testing for Multi-drug Resistance

A total of 37.1% (63/170) of all TB cases and 60.0% (57/95) of new M+ cases diagnosed in 2010 had sputum cultures, including 86.0% (49/57) of new M+ cases from Satun Hospital, 24.1% (7/29) from La-ngu Hospital and 11.1% (1/9) from Khuan Don Hospital. Duration between sending specimen and receiving result was normally 2-5 months. Among 63 cases with sputum cultures, 58 cases got drug sensitivity results,

Table 2. Duration between diagnosis and reporting to 3 tuberculosis reporting systems in Satun Province, Thailand, 2010

Hospital	R506[1]		Bureau of TB[2]		National Health Security Office[3]	
	Number of case	Median day (P_{25},P_{75})	Number of case	Median day (P_{25},P_{75})	Number of case	Median day (P_{25},P_{75})
Satun Hospital	47	3 (2,5)	78	10 (7,17)	70	2 (1,12)
La-ngu Hospital	23	52 (29,88)	41	1 (0,8)	37	1 (0,8)
Khuan Don Hospital	10	55 (20,98)	13	3 (2,5)	9	4 (2,8)
Total	80	6 (2,40.5)	132	8 (1.5,16)	116	2 (0,9)

[1] *Chi-square = 41.6, p-value <0.001* [2] *Chi-square = 26.1, p-value <0.001* [3] *Chi-square = 2.1, p-value = 0.35*

with 20.7% (12/58) resistance to isoniazid and 5.2% (3/58) to rifampicin. Three cases resistance to both isoniazid and rifampicin were MDR-TB. Three out of four cases (75.0%) who had AFB positive after two months were cultured.

Treatment Outcome

Conversion rate of all TB cases reviewed from the hospitals were 95.7% (89/93), which was quite close to 96.7% (88/91) reported in BTB (TB07/1). Out of 155 cases who completed treatment, 55.5% cases were cured and 21.3% had complete treatment while others were loss to follow up (11.0%), death (7.7%) and cases with transfer out, treatment failure or unknown outcome (4.5%). Success rates of all cases and new M+ cases diagnosed were lower than that of reported in BTB during January to June 2010 (Figure 3). Outcome of 22 cases unregistered in BTB during 2010 were loss to follow up (48%), treatment success (29%) and death (14%), which were different from treatment success (84%), death (7%) and loss to follow up (5%) of total 148 reported cases.

Figure 3. Success rate of tuberculosis cases registered in Bureau of Tuberculosis (TB08) and reviewed from 3 hospitals in Satun Province, Thailand, 2010

Usefulness of Surveillance Data

Data from the three systems were used to monitor TB situation and effectiveness of TB control program. The R506 data was used for monitoring trend of incidence, contact tracing and outbreak detection by PHO. Although outbreaks were identified by reviewing each TB cases by PHO, no TB outbreak had been detected up to present. Based on the registered data in BTB, directly observed treatment strategy (DOTS) had been conducted by health volunteers and health centers, and HIV test had been done in 98.2% (163/166) of TB cases registered in 2010 to identify HIV and TB high risk population, which included 34 HIV positive cases. Data of NHSO was used for reimbursement from the hospitals, and conversion rate and success rate in BTB were used to allocate incentive budget from NHSO.

Support for TB Surveillance

Funding and human resources for TB reporting were sufficient for the hospitals and PHO in Satun. There was one staff responsible for R506, and 1-2 staff responsible for BTB and NHSO. A conference to update TB situation and surveillance was conducted annually at regional level, twice a month at provincial level and monthly at district hospitals. However, laboratory personnel were less involved in work plan, and training on data management and adverse effects of treatment were not systematically monitored in the hospitals.

Discussion

Although the three TB reporting systems in Satun Province had different aim and usefulness, all had good capacity to achieve the major objectives of TB surveillance system and their specific objectives, and provided essential information to ensure detection, treatment outcome and monitoring of high-risk population. However, the systems had many reporting forms and complex variables (295 variables in total) which resulted high workload in local level. Coverage and timeliness could be further improved as well. Although the R506 form was simple and easy to use, some hospitals had long lag from diagnosis to reporting in R506 because TB was just one of 84 notifiable diseases in the system and an additional reporting system to a functional BTB system. Moreover, some hospitals had long reporting time and PPV of new M+ was slightly lower than overall PPV since some hospitals also reported new smear negative TB cases. Despite BTB provided more details for monitoring of TB control, it was still complicated. Although NHSO was an online reporting system, it was time consuming for reporting many variables and not easy to access. Completeness of sputum results and treatment outcome in NHSO were lower than it should be due to loss to follow up of some cases and no alert system for data completeness. Although NHSO had the best timeliness of reporting, the data was not used to monitor disease trend or outbreak.

The best method for measuring TB incidence was through a routine surveillance system that captured reliable and comprehensive data on new cases of TB.[4,18] Surveillance systems (TB specific recording and reporting systems and/or general health information systems) should be strengthened until notification was considered to be a direct measure (or

close proxy) of TB incidence.[4,19] In this study, the coverage of TB cases was closed to the CDR which was widely used as an indicator of national progress in TB control since the mid-1990s.[4] CDR for all cases of TB in Thailand during 2009 was 69% which was lower than coverage of all TB cases in BTB and NHSO.[13] In addition, the case notification rates of all types of TB and new M+ in three districts during 2010 were lower than the WHO estimated rates for Thailand of 137 and 66 per 100,000 population.[4] It might be due to the fact that data from WHO was estimated for the whole country, but not just for Satun Province. Another reason was that some TB cases were not detected and caused under-reporting.

In this study, high conversion rate of TB treatment in surveillance data was quite close to the result from the reviewed data, which might imply that appropriate treatments were provided to patients. However, both success rates of all TB cases and new M+ cases were lower than those reported in BTB. Main reason might be over-estimation on treatment outcome of under-reporting cases. However, the success rate reviewed from the hospital data still did not reach the national goal of 90%.[9]

Limitations

Reviewing of all medical records was not completed as some OPD charts could not be found. Foreigner and prisoner cases were excluded in our case definition due to unavailable information, which might underestimate the coverage and PPV of R506. Quality of doctor diagnosis was not assessed in this study, which might over-estimate the performance of surveillance and TB control program. As the TB reporting systems were complicated and included much information, longer study period was needed to verify some unusual data.

Recommendations

In this study, some recommendations were generated for improving TB surveillance and reporting systems at local and central levels. In local health departments, these three systems could be sustained and improved with support and coordination from TB centers, PHO and relevant partners through continuous monitoring and evaluation. More training was needed to improve timeliness of reporting in some hospitals and only new M+ cases should be reported in R506. Laboratory personnel should involve more in work plan and be trained on data management.

In addition, BOE should effectively monitor R506 system, especially on TB case definition for reporting. In BTB system, patients should be registered when they received anti-TB drugs and adverse effects of treatment should be routinely monitored as well. NHSO should share information of different outcomes to all partners. Reporting of registered TB cases in electronic file and integration of R506, BTB and NHSO systems as one national online TB information system should be considered. Because three systems belong to different departments, it was uneasy to integrate them in a short time. However, R506 and BTB could be combined quickly for reporting all new M+ TB cases under coordination by Department of Disease Control in Ministry of Public Health, Thailand.

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